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In vitro bioactivity and phytochemical screening of *Suaeda maritima* (Dumort): A mangrove associate from Bhitarkanika, India

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ABSTRACT

Objective: To investigate the *in vitro* antioxidant and antimicrobial activities along with phytochemical screening of organic and aqueous extracts of leaf and stem of *Suaeda maritima* (Dumort), a mangrove associate from Bhitarkanika of Odisha, India. **Methods:** Antioxidant activity of the crude extracts was evaluated in terms of total antioxidant capacity, total phenol content, ascorbic acid content, DPPH radical scavenging, metal chelating, nitric oxide scavenging, and reducing power etc. The antimicrobial activity of the plant was determined by agar well diffusion method along with MIC and MBC carried out by microdilution techniques against 10 gram positive and gram negative human pathogenic bacteria. The qualitative and quantative phytochemical screening were carried out by standard biochemical assays. **Results:** Out of the seven antioxidant bioassays, both the leaf and stem extracts were found to posses strong antioxidant properties of 70 % to 92 % for phenol, total antioxidant capacity, DPPH free radical scavenging activity and fairly good ascorbic acid content, metal chelating (1.33 %-22.55 %), reducing power (0.01-0.12) and nitric oxide scavenging (0.84 %-66.99 %) activities. Out of the four extracts evaluated for antimicrobial activity, two leaf extracts such as acetone and ethanol showed promising activity against four pathogenic bacteria and one stem methanol extracts against one pathogenic bacteria when compared with amoxycillin as standard. The MIC and MBC values of the antimicrobial extracts ranged between 2.5 to 5.0 mg/mL. Screening of phytochemicals showed presence of carbohydrates, protein, tannins, alkaloids and flavonoids in comparatively higher amount than other phytochemicals tested. **Conclusions:** The present study reveals the presence of potential antioxidants and antimicrobial properties in the plant extract which could be exploited for pharmaceutical application.

1. Introduction

The extensive use of natural plants as primary health remedies due to their pharmacological properties is quite common. Natural products are preferred for biologically screening based on ethno-medical use of plants, because many infectious diseases are known to have been treated with herbal remedies throughout the history of mankind[1]. The investigation of the efficacy of plant-based drugs has been paid great attention because of their few side effects, cheap and easy availability[2, 3]. The plants used in traditional medicine are still a large source of natural antioxidants, antimicrobials, anticancer agents that might serve as leads for the development of novel drugs[4]. Nowadays there has been focus on study of antioxidants from plant origin that produce their effect on reactive oxygen species (ROS) and are thus helpful in producing health benefits through protecting our body. The principal agents responsible for the protective effects against reactive oxygen species could be the presence of antioxidant substances that exhibit their effects as free radical scavengers, hydrogen donating compounds and metal chelators[5]. Thus, search for antioxidant principles from plants has been accelerated and many plants having potential antioxidant activities have been identified and is under use[6]. Apart from this, growing misuse of antibiotics and chemotherapeutic agents leading to drug resistance[3, 7-9] is now also pushing a considerable proportion of people in both developed and developing countries to the use of herbal medicines which are not only cheap but also safe to use. Natural antimicrobial components in plants can also inhibit the growth of

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bacteria by unknown mechanisms other than that of known antibiotics[3].

Mangroves are salt tolerant plants growing in the tropical and subtropical intertidal regions of the world largely confined to the region between 30° north and south of the equator[10]. They are highly resistant to salinity and tidal fluctuations and they are known to be a source of several bioactive compounds and secondary metabolites like alkaloids, phenolics, tannins, flavonoids, steroids and terpenoids with toxicological, pharmacological and ecological importance[11]. Nowaday several mangrove species are being used in traditional medicine or have found applications as insecticides and pesticides and thus attracted the attention for pharmaceutical and other industries. Use of mangroves as potent source of natural antioxidant and antimicrobial agents in various herbal medicines for the treatment of diseases like cancer, diabetes, HIV etc has been reported by various authors[10, 12-15]. Very limited reports on antibacterial, antioxidant and many other biological activities have been published in Indian mangroves[9, 10]. *Suaeda maritima* (L.) (*S. maritima*) Dumort a herbaceous mangrove associated plant widely distributed on the landward margin of mangrove habitats of Bhitarkanika has been used as leafy vegetable for making juice and curries, feeding cattle, goats and sheep[9, 10]. It has been reported that the local vaidyas used the juice of this herb for treatment of Hepatitis. In the present study an attempt was made to evaluate the antioxidant and antimicrobial activities besides presence of phytochemicals in leaf and stem extracts of Suaeda maritima with a view to evaluate the bioefficiency of the plant for its possible pharmaceutical applications.

2. Materials and methods

2.1. Plant material

Fresh, young and tender leaves and stem of *S. maritima.* were collected from the mangrove forest of Bhitarkanika wildlife sanctuary which extends from 20 ° 30′ to 20 ° 50′ latitude and 86 ° 30′ to 87 ° 60′ E longitude. The specimens were identified at Department of Natural Products, Institute of Minerals and Materials Technology, Bhubaneswar (RRL-B), Orissa. India and voucher specimen (VS No. RRL-B 12562) was deposited.

2.2. Preparation of plant extract

The leaves and stem of the plant were dried for 15 days and then pulverized into fine powder using mechanical grinder. 25 g of fine powder was added to a conical flask along with different solvents (acetone, ethanol, methanol and water) for extraction of phytochemicals[16]. Percentage yield was calculated from the dry extract powder.

2.3. Antioxidant activity

Total phenolic content was estimated according to the methods of Slinkard and Singleton[17] using catechol as standard phenolic compound. The phenol content was expressed in terms of % dry weight. The ascorbic acid content was estimated following the methods of Swain and Tripathy[18] with slight modifications. The ascorbic acid content was expressed in % dry weight. Total antioxidant capacity of plant extracts was determined by Prieto *et al*[19]. The absorbance was measured at 695 nm against blank and the results were expressed as mg catechol equivalent/g dry weight (DW). The reducing power of solvent extracts of leaves and stems of S. *maritima* was determined by the method of Oyaizu[20]. The absorbance was measured at 700 nm in a spectrophotometer. The DPPH (2,2-diphenyl -1-picryl hydrazyl) radical scavenging effect was determined by following modified methods of Patra *et al*[14]. The absorbance of all the sample solution was measured at 517 nm by using spectrophotometer (Systronics 114). The % scavenging effect of the plant extract against DPPH free radical was calculated from the following equation.

$$\% \text{ Scavenging} = (A_0 - A_1) / A_0 \times 100$$

Where A_0 is the absorbance of control. A_1 is the absorbance of test sample.

The ferrous ion chelating activity was assessed as described by Zhao *et al*[21]. The absorbance was measured at 562 nm. BHT was used as a positive control. The metal chelating effect of the plant extract was calculated from the following equation.

$$\text{Metal chelating effect } (\%) = (A_0 - A_1) / A0 \times 100$$

Where A_0 is the absorbance of control. A_1 is the absorbance of test sample.

Nitric oxide scavenging activity was assessed by Griess reaction method[22]. The absorbance of the chromophore formed was measured at 546 nm. The percentage inhibition of nitric oxide generated was measured by comparing the absorbance values of control and test compounds from the following equation.

$$\text{Nitric oxide scavenging activity } (\%) = (A_0 - A_1) / A_0 \times 100$$

Where A_0 is the absorbance of control. A_1 is the absorbance of test sample. BHT was used as reference standard.

2.4. Antimicrobial activity

Ten pathogenic bacteriaviz. *Staphylococcus aureus* (MTCC 1144), *Shigella flexneri* (Lab isolate), *Bacillus licheniformis* (MTCC 7425), *Bacillus brevis* (MTCC 7404), *Vibrio cholerae* (MTCC 3904), *Pseudomonas aeruginosa* (MTCC 1034), *Streptococcus aureus* (Lab isolate), *Staphylococcus epidermidis* (MTCC 3615), *Bacillus subtilis* (MTCC 7164) and *Escheri coli* (MTCC 1089) used in the study were obtained from Institute of Microbial Technology, Chandigarh and others were lab isolates. The organisms were maintained on nutrient agar (Hi Media, India) slopes at 4 ℃ and subcultured before use.

Agar cup plate method[23] was carried out to establish the antibacterial activity of all the four solvent extracts against the test pathogens. Wells of 6 mm diameter were punched over the agar plates using sterile gel puncher (cork borer). 100 μL (50 mg/mL) of extract were poured into the wells. The plates were incubated at 37 ℃ for 24 h. The zone of the clearance around each well after the incubation period, confirms the antimicrobial activity of the respective extract. Amoxycillin (35 μg/disc) was used as standard. Minimal inhibitory concentration (MIC) was determined by two fold microdilution method[24]. Minimal inhibitory concentration and minimal bacteriocidal concentration (MBC) was seen

on those bacterial strains which showed zones of inhibition against the plant extracts. The following formula was used for comparison of the antimicrobial activity of the sample with that of the standards (antimicrobial index).

$$\text{Antimicrobial index} = \frac{\text{Inhibition zone of sample}}{\text{Inhibition zone of the standard}} \times 100$$

2.5. Phytochemical analysis

A qualitative phytochemical test to detect the presence of alkaloid, tannin, saponin, flavonoid, cardiac glycosides, sterols, anthroquinone glycosides, carbohydrates and protein was carried out using standard procedures[11, 25] and quantitative phytochemical test for determination of proteins, carbohydrates, falvonoid, alkaloids, ravoflavin, thiamine, tannins and free amino acid[11, 25-26] and nitrogen, potassium, phosphorous, potassium pentoxide, potassium dioxide[27] was carried out using standard procedures.

2.6. Statistical analysis

All the experiments were carried out in triplicates and the data was expressed as mean value ± standard deviation. Correlation analysis between different antioxidant assays and between TAC, PC and ASA were carried out using the correlation programme in MINITAB Software.

3. Results

3.1. Antioxidant activity

The antioxidant potential of the solvent extracts of leaves and stems of *S. maritima* was evaluated using different bioassys such as DPPH scavenging assay, reducing assay, chelation of metal ion, nitric oxide scavenging assay, phenol content, ascorbic acid content and total antioxidant capacity. DPPH radical scavenging activity (%) of the solvent extracts were given in Figure 1. Higher DPPH radical scavenging activity were shown by the acetone leaf extract (80.84±0.155 %) and the ethanol stem extract (92.435±0.091 %) which increases with increase in concentration. The result of the study showed that both the leaf and stem extracts showed high DPPH radical scavenging activity but among the two powders, the leaf extracts showed higher activity in all the solvents. The reducing capacity of solvent extracts of the plant was shown in Figure 2. The result suggested that the extract has reducing power, which increased with increasing amount of concentration. The metal chelating activity of all the four extracts at three different concentrations (50, 75 and 100 μg/mL) were shown in Figure 3. These results showed that the extract has metal chelating activity which increases with increase in concentration of plant extract. The nitric oxide scavenging activity of the solvent extracts were shown in Figure-4. The phenol content in acetone, ethanol, methanol and aqueous extracts of the leaf powder was found out to be 1.466±0.012, 0.77±0.004, 0.612±0.012, 0.475±0.007 % DW respectively and that of the stem powder was found out to be 0.34±0.008, 0.33±0.001, 0.172±0.002 and 0.48±0.05 % DW respectively (Table 1). The extracts of *S. maritima* were good sources of ascorbic acids and the result were summarized in Table 1. The result was expressed as mg catechol equivalent per gram DW. The results of the different antioxidant assays used in the present investigation of different solvent extracts of leaf and stem powder of *S. maritima* were compared and correlated with each other.

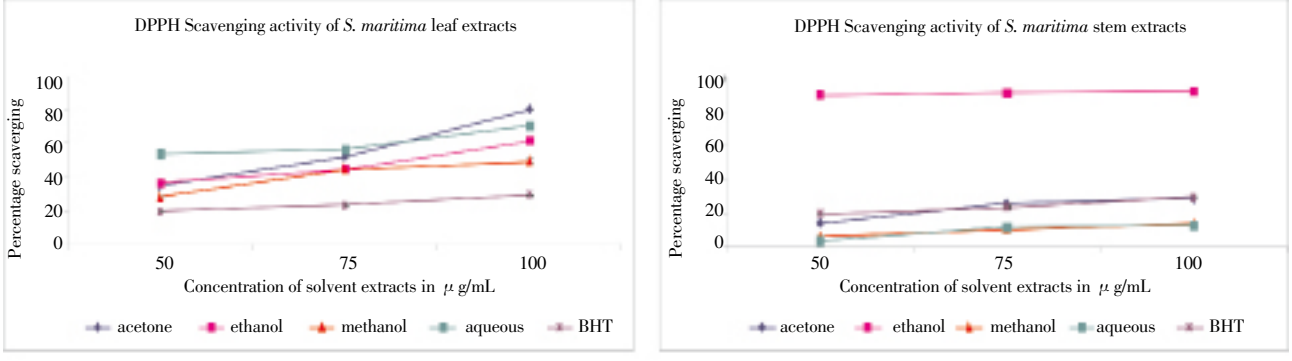

Figure 1. DPPH radical scavenging activity of leaf and stem extracts of *S. maritima*.

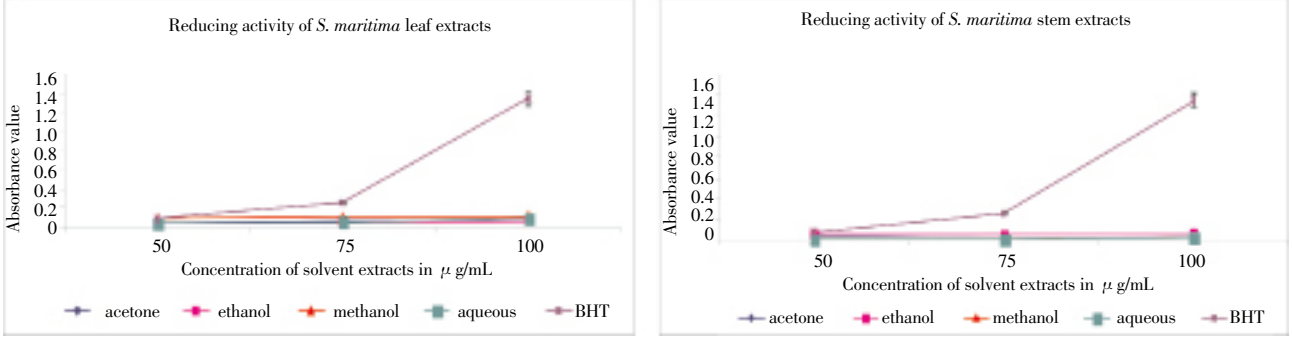

Figure 2. Reducing capacity of leaf and stem extracts of *S. maritima*.

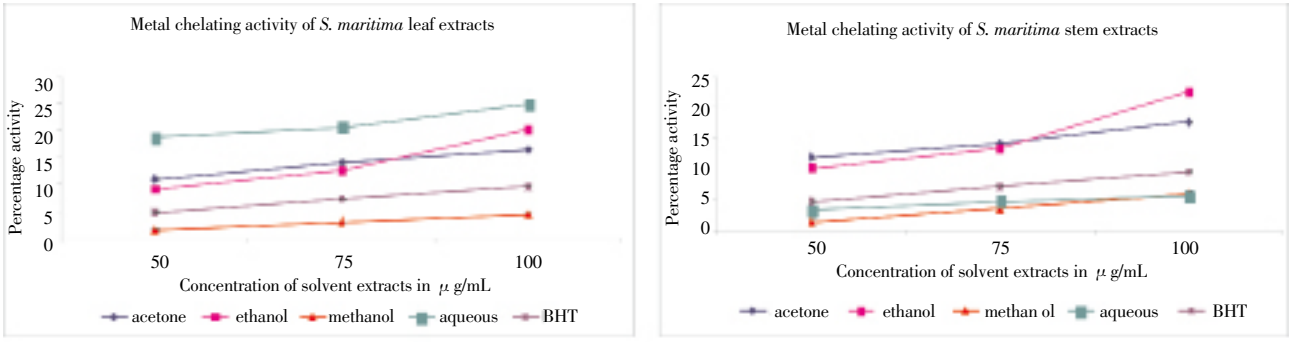

Figure 3. Metal chelating activity of leaf and stem extracts of *S. maritima*.

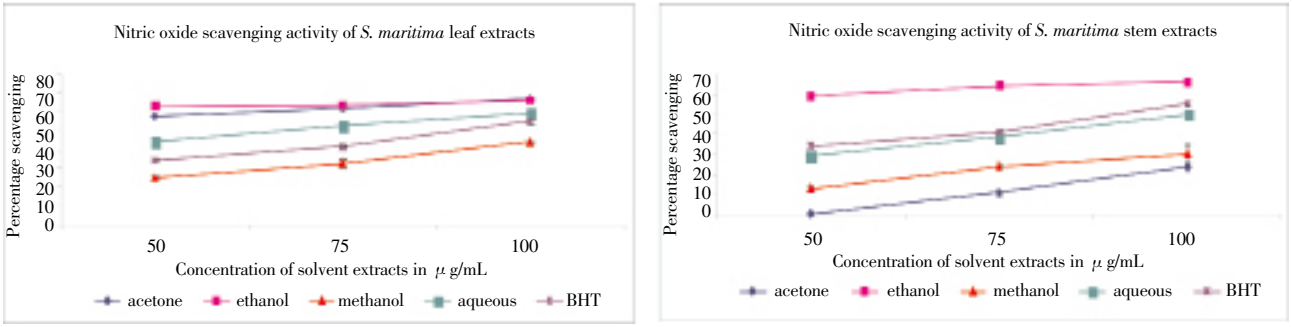

Figure 4. Nitric oxide scavenging activity of leaf and stem extracts of *S. maritima*.

3.2. Antimicrobial activity

The antimicrobial activity of the leaf and stem extracts (acetone, ethanol, methanol and aqueous) of *S. maritima* was assayed *in vitro* by agar well diffusion method against ten bacterial strains (Table 2). Result on antimicrobial activity of those strains found positive have been shown in the table while others without any activity have been excluded in the table, The acetone extract of leaves was more effective against *Vibrio cholerae, Staphylococcus epidermidis, Bacillus subtilis* and *Escherichia coli* with inhibition zone ranging from 9–14 mm whereas it showed no antimicrobial activity against *Bacillus brevis, Shigella flexneri, Bacillus licheniformis, Pseudomonas aeruginosa* and *Staphylococcus aureus* (Table 2). On the other hand ethanol leaf extract showed antimicrobial activity against only *Pseudomonas aeruginosa* (11 mm), *Staphylococcus epidermidis* (12 mm) and *E. coli* (9 mm). The methanol extract and aqueous extracts of the leaf do not show any activity against all the tested microorganisms (Table 2). But the methanol extract of the stem was only effective against *Staphylococcus epidermidis* (11 mm) where as all other extracts do not show any activity against the microorganisms. The significant antimicrobial activity of the active plant extracts was compared with standard antibiotic amoxycillin (35 μg /disc) (Table 2). The antimicrobial index was calculated with the standard antibiotic, amoxycillin (Table 2). The result showed that the antimicrobial index ranged between 27% to 140 % in acetone and ethanol leaf extract. MIC was determined by twofold micro dilution method. MIC values of the leaf and stem extracts was found out to be 2.5 mg/mL and MBC value was found to be 5 mg/mL (Table 2) so as to exhibit their growth to know the efficacy of the plant extracts.

3.3. Phytochemical screening

Preliminary phytochemical screening of the leaf and stem extracts showed that the solvent extracts contain most of the phytochemicals like alkaloids, steroids, tannins, saponins, ascorbic acid etc whereas gums and mucilages are not found in any of the extract (Table 3). The quantative phytochemical screening of the powder of leaf and stem of *S. maritima* was shown in Table 4. The results showed that the stem powder contains more amount of thiamine (0.273 % DW), flavonoids (1.08 % DW), ravoflavin (0.017% DW), carbohydrates (10.47% DW), phosphorous (0.48% DW), potassium (0.49% DW), phosphorous pentoxide (1.104 % DW) and potassium dioxide (0.588 % DW) as compared to the leaf powder.

4. Discussion

The results of the present study suggested that the DPPH scavenging activities are shown by all the solvent extracts in both leaf and stem powder extracts. DPPH assay is widely used as a model system in the assessment of scavenging activities of several natural compounds. DPPH radical is scavenged by antioxidants through the donation of protons forming the reduced DPPH[28]. Our results showed high DPPH scavenging activity. Many researchers have been reported positive correlation between free radical scavenging activity and total phenolic compound which also corroborates with our finding. The reducing capacity of a compound may serve as indicator of its potential antioxidant capacity[29]. The antioxidant activity is system –dependent. Moreover, it depends on the method adopted and the lipid system used as substrate. The antioxidant scavenging capacity of compounds has been attributed to various mechanisms, prevention of chain inhibition, chelating metals, reductive

Table 1
Total antioxidant capacity, phenol and ascorbic acid content of leaf and stem extracts of *S. maritime*.

Solvent extracts	Total antioxidant capacity (mg catechol equivalent per g DW)		Total phenol content (% DW)		Ascorbic acid content (% DW)	
	Leaf	Stem	Leaf	Stem	Leaf	Stem
Acetone extract	25.450±0.640	14.375±0.880	1.466±0.012	0.340±0.008	0.2620±0.009	0.340±0.001
Ethanol extract	11.875±0.880	37.230±1.030	0.770±0.004	0.330±0.001	2.674±0.030	0.490±0.004
Methanol extract	42.723±0.660	37.790±0.330	0.612±0.012	0.172±0.002	4.959±0.002	0.810±0.010
Aqueous extract	62.860±4.040	20.480±0.250	0.475±0.007	0.480±0.050	4.474±0.007	0.430±0.002

All data are expressed in Mean±SD (Standard deviation).

Table 2
Antimicrobial activity of leaf and stem extracts of *S. maritima* against pathogenic microorganisms.

Strains	Acetone leaf extract			Ethanol leaf extract			Methanol stem extract			Amoxcycillin (35 μg/disc)
	IZ	MIC/MBC	AI	IZ	MIC/MBC	AI	IZ	MIC/MBC	AI	
V. cholerae	11.00±0.21	2.5/5.0	0.00±0.00	0.00±0.00	–	0.00±0.00	0.00±0.00	–	0.00±0.00	0.00±0.00
P. aeruginosa	0.00±0.00	–	0.00±0.00	11.00±0.15	2.5/5.0	100.00±0.15	0.00±0.00	–	0.00±0.00	0.00±0.00
S. epidermidis	12.00±0.15	2.5/5.0	109.09±0.15	12.00±0.21	2.5/5.0	109.10±0.21	11.00±0.00	2.5/5.0	100.00±0.00	11.00±0.00
B. subtilis	14.00±0.24	2.5/5.0	100.00±0.24	0.00±0.00	–	0.00±0.00	0.00±0.00	–	0.00±0.00	–
E. coli	14.00±0.00	2.5/5.0	140.00±0.00	9.00±0.00	2.5/5.0	90.00±0.00	0.00±0.00	–	0.00±0.00	10.00±0.00

"IZ"= inhibition zone in mm, "AI"= antimicrobial index in percentage, "0–"= Not detected, All data are expressed in Mean±SD.

Table 3
Qualitative phytochemical analysis of extracts of *S. maritime*.

Test group	Acetone extract		Ethanol extract		Methanol extract		Aqueous extract	
	Leaf	Stem	Leaf	Stem	Leaf	Stem	Leaf	Stem
Alkaloid	+	+	+	+	+	+	+	+
Protein and amino acids	–	–	–	–	–	–	–	–
Carbohydrates	+	+	+	+	+	+	+	+
Cardiac glycosides	+	+	+	+	+	+	+	+
Anthroquinone glycosides	–	–	–	–	+	+	+	–
Tannin and phenolic compound	+	+	+	+	+	+	+	+
Steroids and sterols	–	–	+	+	–	–	+	+
Saponins	–	–	–	–	–	–	–	–
Flavonoids	–	+	–	+	+	+	+	+
Gums and mucilages	–	–	–	–	–	–	–	–

'+' = Present, '–' = Absent.

Table 4
Quantative phytochemical analysis of leaf extracts of *S. maritima*.

Sl. No.	Qntitative phytochemicals	Suaeda maritima different parts	
		Leaf (% DW)	Stem (% DW)
1.	Thiamine	0.093±0.007	0.237±0.005
2.	Flavonoids	0.840±0.002	1.080±0.009
3.	Tannin	2.360±0.010	2.120±0.009
4.	Alkaloid	1.500±0.006	0.660±0.004
5.	Ravoflavin	0.010±0.001	0.017±0.001
6.	Carbohydrates	7.910±0.050	10.470±0.070
7.	Protein content	5.060±0.060	4.875±0.090
8.	Total free amino acids	0.000±0.000	0.000±0.000
9.	Nitrogen content	0.810±0.005	0.780±0.005
10.	Phosphorous content	0.450±0.008	0.480±0.007
11.	Potassium content	0.470±0.006	0.490±0.005
12.	Phosphorous pentoxide	1.035±0.010	1.104±0.020
13.	Potassium dioxide	0.564±0.006	0.588±0.005

All data are expressed in Mean±SD.

capacity and radical scavenging[30]. Concentration dependency of antioxidant activity was investigated as a function of reducing power as this gave a general view of reductones present in the sample. Reducing power increased with increasing concentrations in all the samples. Same trend has also been reported by Banerjee *et al*[12] in methanol extracts of higher plants. This property is associated with the presence of reductones that are reported to be terminators of free radical chain reaction[31]. Ferrozine can quantitatively chelate with Fe^{2+} and form a complex with a red colour. This reaction is limited in the presence of other chelating agents and results in a decrease of red colour of Ferrozine-Fe^{2+} complexes. Measurement of the colour reduction estimates the chelating activity to compete with Ferrozine for Ferrous ions[32]. Our result showed that the solvent extracts possess high metal chelating activity.

Phenolic compounds are commonly found in plants and have been reported to have several biological activities including antioxidant activity. In our studied plant part we found higher amount of phenolic compound which is the indication of its strong antioxidant capacity. There are reports that phenolic compounds are one of the most effective antioxidants[33]. Earlier workers have found that the plant is rich source of phenol and ascorbic acid, which corroborates with our findings[12]. Natural ascorbic acid is vital for the body performance[34]. Lack of ascorbic acid impairs the normal formation of intercellular substances throughout the body, including collagen, bone matrix and tooth dentine, a striking pathological change resulting from this defect is the weakening of the endothelial wall of the capillaries due to a reduction in the amount of intercellular substances[34]. This function of ascorbic acid also accounts for its requirement for normal wound healing. The strong antioxidant activity of solvent extracts of *S. maritima* might be attributed to the presence of photochemical such as phenolic compound[35]. Recent studies have shown that many flavonoids and related polyphenols contribute significantly to the total antioxidant activity of many fruits such as Red grape[36], vegetables[37], and medicinal plants[38].

The content of total phenol (PC) showed positive correlation with most of the antioxidant assays such as NOS ($r = 0.404$), DPPH scavenging ($r = 0.030$) and reducing power ($r = 0.118$) in the extracts of stem powder whereas the leaf powder showed positive correlation with DPPH scavenging ($r = 0.663$) and NOS ($r = 0.555$). Some authors have reported good positive correlations between antioxidant activity tests and total phenol content of the plant material[39-42]. The content of total antioxidant capacity showed good correlation with ascorbic acid content in both leaf ($r = 0.635$) and stem ($r = 0.775$) extracts. There was also good relation among different antioxidant assays. Correlation analysis indicated that the DPPH scavenging activity showed good correlation with metal chelating activity in both leaf ($r = 0.624$) and stem ($r = 0.870$) extracts of *S. maritima*. And NOS has good correlation with metal chelating activity in leaf ($r = 0.744$) and stem ($r = 0.345$). There was moderate or little correlation with most of the other assays. This may be due to the fact that many other compounds such as carotinoids, tocopherol and total flavonoids other than total phenol and ascorbic acid content also contribute to antioxidant activity[42]. The differences in correlation coefficient among different antioxidant methods indicate that a single assay or experiment cannot be used to assess the total antioxidant activity[42].

Drug resistance in human pathogenic microorganisms has developed due to indiscriminate use of commercial antimicrobial drugs commonly used in the treatment of infectious diseases. This condition has forced scientists to search for new antimicrobial substances from various sources[43]. *In vitro* evaluation of plants for antimicrobial property is the first step towards achieving the goal for developing eco-friendly management of infectious diseases of humans by search for new biomolecules of plant origin. Considering these, the leaf and stem of the mangrove associate, *S. maritima* was screened *in vitro* for antibacterial activity against ten human pathogenic bacteria. On the basis of zone of inhibition, the result of the present investigation revealed that the plant is active against both gram-negative bacteria and gram-positive bacteria. In case of solution with low activity, a large concentration or volume is needed. In general gram-positive bacteria are considered more sensitive than gram-negative bacteria towards different antimicrobial compounds because of the difference in the structure of their cell walls[44] but the present result showed that the extracts are effective against both gram-positive and gram-negative bacteria. Antimicrobial properties of substances are desirable tools in the control of harmful microorganisms especially in the treatment of infectious diseases and in food spoilage. The active components usually interfere with growth and metabolism of microorganisms and prevent them from contamination[45].

The solvent extracts of both leaf and stem showed presence of many phytochemicals. The presence of such phytochemicals may be correlated with the fact that solvent extracts showed maximum activity against the bacterial strains. Several phenolic compounds like tannins found in plant cells are potent inhibitors of hydrolytic enzymes used by plant pathogens. A number of studies have been focused on the biological activities of phenolic compounds, which are potential antioxidants and free-radical scavengers[31]. These bioactive components of the plants which are naturally occurring in most plant materials are known to be bactericidal, pesticidal and fungicidal in nature thus conferring the antimicrobial property of this plant. These phytochemicals like phenolic compounds (tannins) present in the extract of these spieces are potent inhibitor of microbial growth. Other compounds like saponins also have antifungal properties. The presence of bioactive substances have been reported to confer resistance to plants against bacteria, fungi and pests and therefore explains the antibacterial activity of plant extracts Many plants release phenolic compounds that are toxic to microbial pathogens[46]. The presence of more amounts of alkaloids in the leaf powder and less amount in the stem powder may be due to variations of alkaloid distribution in the different plant parts. Harborne[47-61] reported that alkaloids have about 9%-10% distribution in vascular plants and are specific to a few related plants. Alkaloid detection in plants is dependent on factors such as age, climate, plant part, habitat, season, time of harvest, chemical races of plants and sensitivity of alkaloid[62]. Flavonoids on the other hand are potent water soluble antioxidants and free radical scavengers which prevent oxidative cell damage and have strong anticancer activity[34]. Saponin has the property of precipitating and coagulating red blood cells. Some of the characteristics include formation of foams in aqueous solution, haemolytic activity, cholesterol binding properties and bitterness[34]. Pure isolated alkaloids and their synthetic

derivatives are used as basic medicinal agents for analgesic, antispasmodic and antibacterial effect[63]. Tannins have been reported to prevent the development of microorganisms by precipitating microbial protein and making nutritional proteins unavailable to them. It has been found that the investigated plant contained steroidal compounds. It should be noted that steroidal compounds are of importance and interest in pharmacy due to their relationship with such compounds as sex hormones[34]. Hence the compound detected may be responsible for antioxidant and antimicrobial activity of the plant extracts.

The result of the present study showed that both the leaf and stem extracts of *S. maritima* are rich source of natural antioxidant with moderate antimicrobial activities. Though the plant contains most of the phytochemicals in different proportions, the presence of phenolic compounds, tannins, flavonoids are particularly important for expressing various bioactivities. Since this herb is used as food and feed, its use is highly beneficial for both human and animal. This plant may be exploited in preparation of herbal drugs with modern standard of safety and efficacy to meet the health care need. It can also be used to formulate new and more potent natural antioxidant and antimicrobial drugs with much bioefficiency in pharmaceutical applications.

Conflict of interest statement

We declare that we have no conflict of interest.

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